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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAMME OF THE

ST. LOUIS MEETING

AT

WASHINGTON UNIVERSITY

ST. LOUIS

November 30–December 1, 1945

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The American Physical Society

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of the

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NOVEMBER 12, 1945 Vol. 20, No. 4

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

ST. LOUIS MEETING, NOVEMBER 30–DECEMBER 1, 1945

THE 268th meeting of the American Physical Society will be held at St. Louis, Missouri, in Wayman Crow Hall of Washington University, on Friday, November thirtieth and Saturday, December first, 1945. Among its major features will be a Symposium of invited papers on x-rays, arranged in celebration of the fiftieth anniversary of the discovery of x-rays, which coincides within the month. The ending of the war has enabled us to hold this timely observance, and should conduce to a spirit very different from that of the meetings of the past four years.

Hotels. The restrictions on meetings have ceased, but the hotel situation is none the better. Two notices have been sent to our members to urge early reservations, and this third notice may arrive too late. Space was however made available at six hotels: Chase, Coronado, Gatesworth, Jefferson, Park Plaza, and Statler. Members may be obliged to share twin-bed rooms if all are to be accommodated.

Access to Washington University. The No. 93 Lindell bus passes all of these hotels: allow 50 minutes from the Statler or Jefferson, 35 minutes from the Coronado, 25 minutes from the Chase and Park Plaza and 15 minutes from the Gatesworth. Leave the bus at Lindell and Skinker, and walk 5 minutes on the campus. The No. 11 University and No. 14 University Clayton street cars following Olive Street and Waterman Avenue, pass within two or three blocks of the hotels, and take about the same time. Leave the car at Limit Way, and walk 3 minutes on the campus.

Dinner. The dinner of the American Physical Society will be held at the Gatesworth Hotel, Union Avenue and Lindell Boulevard, at seven o'clock on Friday evening, November 30. The price is $2.50, tax and tips included. Formal attire is not required but is no longer deprecated. Places at the dinner cannot be guaranteed except to whose who fill out and mail the form printed on the inside back cover page, and perhaps not even to those who do not do so promptly, since the capacity of the dining-room is limited. Tickets will be sold at the registration desk.

The **registration desk** will be located in Room 105 of Wayman Crow Hall, and all members and guests are requested to register.

The **Council** will meet in Room 107, Wayman Crow Hall, at eleven-thirty o'clock on Friday morning.

Entertainment. Tea will be served for members and guests in the lounge of Brown Hall (on the campus) on Friday afternoon, and luncheon will be arranged for visiting ladies on Saturday.

Prospective meetings. The Society will meet at the University of California at Los Angeles on Saturday, January 12, 1946 and at Columbia University, New York City, on Thursday, Friday, and Saturday, January 24, 25, and 26, 1946. The hotel situation in New York is extremely difficult, and members are urged to seek reservations **immediately** from the hotels of their choice. Those who await the appearance of the New York *Bulletin* to make up their minds are likely to have their minds made up for them.

The hotel situation in Los Angeles is not known at this office but is not supposed to be easy.

General Rules Relating to Papers

By vote of the Society on December 27, 1940, no paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for the meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

Karl K. Darrow, *Secretary*
American Physical Society,
Columbia University, New York 27, New York

PROGRAMME

FRIDAY MORNING AT 10:15 O'CLOCK

Room 101, Wayman Crow Hall

(G. W. STEWART presiding)

Invited Paper

A1. Notes on the Optics of Organic Glasses. G. A. BOUTRY, *Conservatoire National des Arts et Métiers, Paris.* (35 min.)

Contributed Papers

B1. Decade Counting Circuits. VICTOR H. REGENER, *University of Chicago.*—Pentodes are used in two simple ring-of-ten circuits for high speed counting of pulses from Geiger tubes or for accurate frequency measurements. One circuit uses in one ring ten miniature poentodes type 6AK6, thirty resistors and ten condensers. This circuit is especially suited for the counting of sharp pulses. The other circuit uses in one ring ten twin-pentodes type 12L8-GT, twenty resistors, and no condensers. This circuit is especially suited for frequency measurements of periodic currents of arbitrary wave form and of frequencies from zero to above 10^6 cycles per second. The number of pulses or cycles received by a ring-of-ten is indicated on the screen of a one-inch cathode-ray tube type 913. The spot on the screen has ten possible positions, arranged on a circle, corresponding to the ten states of equilibrium of the ring-of-ten. When counting, the spot moves successively through the ten positions. Several of these ring-of-ten units, each with its cathode-ray tube, can be connected in cascade. Thus, electronic counting with direct indication of the decimal figures is made possible.

B2. Geiger-Muller Counter Technique for High Counting Rates. C. O. MUEHLHAUSE AND H. FRIEDMAN, *U.S. Naval Research Laboratory.*—Counting rates of 100,000 per second have been measured with a self-quenching G-M counter operated at 50 to 100 volts above threshold. The counter was coupled to a video amplifier having linear response to four megacycles per second and a maximum gain between 10^3 and 10^4. The amplified pulses were counted by a scaling circuit capable of responding to uniform pulse rates up to two megacycles per second. The triggered sweep oscilloscope method, devised by Stever* to measure "dead-time," was applied to the present combination of counter and amplifier. At amplifications under ten, a dead-time interval of 3×10^{-4} second was observed, in agreement with Stever's results. At higher amplifications the dead-time pattern persisted but pulses were observed within the deadtime interval. These latter pulses arise from impact ionization in the reduced fields that exist immediately following the formation of a positive ion sheath, and make possible the high counting rates observed.

* H. G. Stever, Phys. Rev. **61**, 38 (1942).

B3. Recurrences of Small Bursts of Cosmic Rays. JAMES W. BROXON, *University of Colorado.*—Upon analysis by Chree's method of superposed epochs, the writer[1] found pulses at about 28-day intervals in the intensity of cosmic radiation measured by Long and Whaley[2] at Boulder during 18 months in 1938–39. In the same investigation, they found indications of both diurnal and seasonal variations in frequency of the smallest bursts they recorded. These bursts corresponded to about 3×10^6 ion pairs in the heavily shielded, spherical chamber of 13.8 liters. Application of Chree's method to the frequency of these small bursts over the n-day range, $-45\leqslant n\leqslant 45$, shows irregular but apparently significant loops. Both preceding and subsequent difference curves indicate pulses with peaks at about 27 days before and after the selected days of high or low frequency of the small bursts. The combination of difference curves formed by the average of frequencies for positive and negative day numbers of the same magnitude agree with the individual difference curves. The secondary pulses correspond to variations of some 3 or 4 percent from the average frequency of 36 small bursts per day.

[1] J. W. Broxon, Phys. Rev. **59**, 773 (1941).
[2] V. A. Long and R. M. Whaley, Phys. Rev. **A59**, 470 (1941).

B4. Experiments on the Elastic Single Scattering of Electrons by Nuclei. R. J. VAN DE GRAAFF, W. W. BUECHNER, AND H. FESHBACH, *Massachusetts Institute of Technology.*—Experiments completed in July, 1941 on the elastic single scattering of electrons by nuclei are described. Observations were made at voltages from 1.27 to 2.27 Mev and at angles from 20° to 50°. The scattering foils were

aluminum, copper, silver, platinum, and gold. The use of an accurately focused homogeneous beam of electrons from an electrostatic generator made possible a clear-cut control of experimental variables, the method being designed to minimize the effect of x-ray background, etc. The present results are in close agreement with the Mott theory over the entire range of the experimental variables except for the case of 2.27 Mev electrons striking aluminum. Excepting only this case, the average of all the ratios of experimental result to theoretical prediction is 1.01 with a standard deviation of 0.07. This is in contrast with the wide divergence in most previous work in this field. The results of this paper extend the range of validity of the Coulomb law of attraction between electron and nucleus in close to the surface of the nucleus. The scattering of 2.27 Mev electrons by aluminum will be repeated as these results now indicate for the larger angles an interesting divergence from theory.

B5. The Lifetimes of Metastable States. MARCELLUS L. WIEDENBECK, *University of Notre Dame.*—Estimates of the lifetime of metastable states of isomeric nuclei against γ-emission have been given by Bethe[1] and Hebb and Uhlenbeck.[2] The latter authors have also proposed a correction for Bethe's lifetimes in order to take into account the additive decay probability brought about by internal conversion. Available data on forty metastable states of nuclei (stable and unstable) have been plotted and compared with the present theories. With only four exceptions, all points lie near two parallel lines when $\log \lambda(\text{sec.}^{-1})$ is plotted against $\log E$ (Mev). These empirical lines are in the region of, and intersect those obtained from Bethe's formula for spin changes of four and five units. The agreement is greatly improved if the correction for internal conversion is taken into account. In the range considered, the agreement with the relationship given by Hebb and Uhlenbeck is less close. Experimental verification of these spin changes can be obtained by measuring the conversion coefficients or, if a sufficient quantity of active material is available, the spin of the isomer may be measured directly.

[1] H. A. Bethe, Rev. Mod. Phys. **9**, 226 (1937).
[2] M. H. Hebb and G. E. Uhlenbeck, Physica **5**, 605 (1938).

B6. Wide and Sharp Neutron Groups. A. A. YALOW* AND M. GOLDHABER, *University of Illinois.*—We have continued our studies of wide and sharp neutron groups. For nuclei of odd charge and odd mass number, of which we have investigated a fairly representative sample, it appears that sharp levels cluster around low neutron energies. The "double filter method"[1] has been extended to further cases (Rh, In, Ir, and Au). In Ir (19*h*) the activity induced by D neutrons can be effectively eliminated by an In filter. The remaining activity, 30 percent in our arrangement, is due to a group with an energy of approximately 50 ev. The absorption in B with and without "self-filtration" has been measured for several wide groups (Br (18 min.), I (25 min.) and As (26.8h)). The absorption decreases with self-filtration, as was known previously for I. It seems plausible that this effect is due to the preferential removal by the filter of the oblique neutron rays from the non-parallel beam. For the remaining "straightened" beam the effective boron thickness is thus decreased.

* Now at the Federal Telephone and Radio Laboratories, New York, New York.
[1] A. A. Yalow and M. Goldhaber, Phys. Rev. **A68**, 99 (1945).

B7. Resonance Scattering of Group Neutrons. M. GOLDHABER AND A. A. YALOW,* *University of Illinois.*—In the course of an investigation of the absorption in B and Mn of the R neutrons activating a Mn detector, and in experiments in which Mn absorbers were used with different detectors, we noticed some anomalies which it seemed possible to explain by assuming that Mn is activated by neutrons from two regions: a broad low energy region (strong absorption in B, weak absorption in Mn) and a resonance region with an energy >50 ev (weak absorption in B, strong absorption in Mn), where strong resonance scattering also takes place. This assumption was tested by a series of experiments in which the primary R neutrons were reflected from Mn, C, and other scatterers, and the secondary neutrons recorded by various group detectors responding to different neutron energies. Mn and Br (18 min.) proved the most sensitive detectors for the secondary neutrons from a Mn reflector. The absorption of the primary R neutron component which is reflected by Mn, was studied in a number of absorbers and was found to be particularly strong in Mn. The resonance character of the scattering in Mn seems thus established.

* Now at the Federal Telephone and Radio Laboratories, New York, New York.

B8. Nuclear Processes by Polarization Scattering of Deuterons. EUGENE GUTH, *University of Notre Dame.*—The deuteron, because of its low binding energy, may be polarized by the field of a nucleus that it strikes. In this way the neutron may come close enough to the nucleus to enable an energy transfer from the deuteron to the nucleus without the necessity of a (d,d) reaction or even excitation by the Coulomb field of the deuteron. This new process by "polarization scattering" is somewhat similar to the well-known Oppenheimer-Phillips process, but differs from it essentially in that the outgoing particle is not a proton but a deuteron. This difference makes it possible to distinguish between the two processes even when the conditions for the O-P-process are fulfilled (kinetic energy of the deuteron larger than its binding energy; medium and heavy nuclei); the same holds for excitation of the nucleus by a deuteron disintegrated by the Coulomb field of the nucleus, and for the ordinary (d,d) reaction mentioned before. As an example for the new process, In^{115} should be excitable by deuterons; this prediction was actually verified by M. L. Wiedenbeck (personal communication), thus proving the existence of polarization scattering. Observation of the inelastically scattered deuterons seems to be a promising method for studying nuclear spectroscopy. Polarization scattering may be used, among other things, to liberate neutrons from Be^9 and D, etc.

FRIDAY MORNING AT 10:15 O'CLOCK

Room 104, Wayman Crow Hall

(E. U. CONDON presiding)

C1. The Photomultiplier X-Ray Detector. FITZ-HUGH MARSHALL AND L. P. HUNTER, *Westinghouse Research Laboratories. (Introduced by J. W. Coltman.)*—To the conventional list of x-ray detectors—photographic film, fluorescent screen, ionization chamber, and Geiger or proportional counter—a new instrument has been added in recent years. It consists of a photo-multiplier tube measuring the light from a fluorescent screen. It has high practical sensitivity, and it is extremely fast, the response time being of the order of microseconds. While it does not show drift of the type usually observed in d.c. amplification of ionization chamber currents, it is sensitive to changes of potential applied to the photo-multiplier tube and is subject to various fatigue effects. The present work has been devoted to studying the characteristics of the photo-multiplier x-ray detector and comparing them with those of the ionization chamber and other x-ray detectors. Particular attention has been given to speed of response and limitation of sensitivity by noise. Fatigue effects have been found to arise in the later stages of secondary emission amplification in the photo-multiplier tube.

C2. Fluorescent Yield of Calcium Tungstate Excited by X-Rays. E. G. EBBIGHAUSEN AND J. W. COLTMAN, *Westinghouse Research Laboratories.*—The fluorescent energy yield from a calcium tungstate screen and its spectral distribution were determined by comparison with the spectrum of a standard tungsten lamp. The energy distribution of the lamp was calculated on the basis of the temperature, the spectral emissivity of tungsten and the transmission of the quartz lamp window. A quartz spectrograph was used, and reciprocity law failure was avoided by appropriate reduction of the light from the lamp. Exposure times varied from twenty minutes to one hour depending on the region of the spectrum. The combined results from seven plates gave a spectral curve extending from 3500A to 6200A with a maximum at 4150A. The total light energy out (after correcting for the angular distribution from the screen) was 14.8 ergs/cm^2 per r-unit incident at 80 kv constant potential with 1 mm aluminum and $\frac{1}{2}$ mm copper filter. Using curves[1] of the energy distribution of the x-rays, the relation between the r-unit and energy for various wave-lengths, and the absorption coefficient of calcium tungstate, the energy absorbed was calculated and an over-all conversion efficiency of 2.8 percent was obtained.

[1] Terry and Ulrey, *X-Ray Technology.*

C3. The X-Ray K Absorption Edge of Silicon. VOLA P. BARTON, *Goucher College,* AND GEO. A. LINDSAY, *University of Michigan.*—Very few measurements of the K absorption edge of silicon have been made. In 1925 Lindh found 6731 x.u. for the wave-length in silicon metal and about 6707 x.u. for silicon in the compounds SiO_2, Na_2SiO_3, and K_2SiO_3. In 1931 Deodhar found for silicon in quartz 6706 x.u. by using quartz as the reflecting crystal. For these wave-lengths it is difficult to prepare screens which are thin enough and still capable of being handled. In the present work reflecting crystals of quartz and of four different micas were used, and in addition silicon and Na_2SiO_3 in a finely powdered form were put on the face of a gypsum crystal. The reference lines were in higher orders, thus necessitating a correction for refraction. By applying the correction for refraction the wave-length of the absorption edge of silicon in all the compounds examined was found to be practically the same—about 6700 x.u., while that of silicon metal was 6716 x.u. If the refraction correction is not made the wave-lengths for the various compounds differ much more among themselves.

C4. X-Ray Energy Level Widths of Tungsten. JOHN N. COOPER, *University of Oklahoma.*—Data on the widths of K^1, L^2, and M^3 series lines of tungsten enable one to estimate the widths of certain energy levels on the assumption that the energy width of any line is the sum of the level widths involved in the transition. If mutually self-consistent widths are assigned to the K, L, and M levels, very large differences arise in the widths of the N_{II} and N_{III} levels as calculated from the breadths of lines involving these states. The differences are far too great to be explained by reasonable experimental errors or by the uncertainties in the corrections applied for crystal diffraction patterns. [The reported width of $M\rho_1(M_VN_{III})$ is ten times the sum of the widths of $M\alpha_2(M_VN_{VI})$ and $M\delta(M_{IV}N_{III})$. As MBS[3] have observed, this is utterly inconsistent with the above assumption.] Accordingly, it appears that the Weisskopf-Wigner theory of line widths is not adequate to explain the observed breadths in all cases.

[1] Richtmyer and Barnes, Phys. Rev. **46**, 352 (1934).
[2] John N. Cooper, Phys. Rev. **61**, 234 (1942).
[3] Mumier, Bearden, and Shaw, Phys. Rev. **58**, 537 (1940).

C5. The Curved Crystal Spectrograph Applied to Determine the Complete Spectrum of All Orders Obtained When the Camera Is Rotated about a Proper Pivot. JOHN W. FARNHAM, J. E. EDWARDS AND F. C. BLAKE, *Ohio State University.*—Using Larsson's value for the index of refraction of α-quartz the attempt is made to compare the Bragg angles for the several orders of Faces 100 and 110 as measured by the powder method and by the curved-crystal spectrograph method. The second order of 130 and 310, however, does not appear since, for this order, the oxygen and silicon atoms practically neutralize one another.

C6. On the Proper Indexing of the Crystal Faces of α-Quartz by the Powder Method and the Calculation of Their Structure Factors for Both Right-Handed and Left-Handed α-Quartz. F. C. BLAKE, *Ohio State University.*—On account of the importance of α-quartz in thin sections in the curved crystal spectrograph[1] tables will be presented for all possible faces of α-quartz as determined by the powder method using the molybdenum $K\alpha$-doublet at 40 kilovolts. Comparison is also made with Bradley and Jay's determinations[2] made with Cu $K\alpha_1$, all of the unindexed lines in their work being properly indexed. Tables of the unreduced structure factors for both right-handed and left-handed quartz will be shown. Comment will be made on the matters of twinning and interpenetration of twins.

[1] E.g., Phys. Rev. **67**, 150 (1945).
[2] Phys. Soc. London **45**, 507 (1933).

C7. Characteristic X-Rays Excited by Beta-Particles. J. E. EDWARDS AND M. L. POOL, *Ohio State University.*—X-ray photographs of 12.8-hour Cu^{64} taken with a curved crystal spectrograph[1] show x-ray lines characteristic of Cu and Ni. Since there is no other evidence for the existence of a genetically related isomeric pair in Cu^{64}, the characteristic Cu x-rays are probably excited by the strong β-activity also present in the 12.8-hour period. Further evidence to support this view was obtained by photographing a piece of inactive Cu foil while it was being bombarded by P^{32} β-particles whose maximum energy is 1.7 Mev. With a P^{32} β-activity comparable with the β-activity in the deuteron activated Cu, x-rays characteristic of Cu were observed. Similar photographs of characteristic x-rays excited by P^{32} β-particles in other elements were obtained. The characteristic x-rays and general x-radiation excited by P^{32} β-particles in Al, Cu, Ag, Sn, and Pb were also studied by absorption of the radiation in Al, Cu, and Pb. The ratio of the intensity of the characteristic radiation to the average intensity of the general radiation is rather high (7 in the case of Ag). Thus the appearance of characteristic x-rays in the presence of a strong β-activity does not always indicate K-capture or internal conversion.

[1] J. E. Edwards, M. L. Pool, and F. C. Blake, Phys. Rev. **67**, 150 (1945).

C8. X-Rays from Radioactive Te. M. L. POOL AND J. E. EDWARDS, *Ohio State University.*—A radioactive isomer has been found in Te^{121} with the aid of a curved crystal x-ray spectrograph. The pair consists of a new 17 ± 1 day activity produced by the reactions $Sb(d, 2n)$ and $Sv(p, n)$ and a previously assigned activity evaluated here as 143 ±5 days. X-ray photographs of characteristic radiation from Te^{121} were taken during various phases of decay extending over a period of 235 days. Sb and Te x-rays, a 0.61-Mev gamma-ray, a 0.223-Mev gamma-ray, and conversion electrons are associated with the long period. Sb x-rays and a 0.61-Mev gamma-ray are associated with the short period. The observations are simply explained by the isomeric transition. No evidence of the "fast" gamma transition[1] was found. Satellite x-ray lines were not observed near the strong characteristic lines.

[1] R. D. O'Neal and Gertrud Scharff-Goldhaber, Phys. Rev. **62**, 83 (1943).

C9. Thickness Measurements of Thin Coatings by X-Ray Absorption. L. S. BIRKS AND H. FRIEDMAN, *U.S. Naval Research Laboratory.*—An x-ray absorption method was applied to the measurement of thin films on thick crystalline or polycrystalline backings. Characteristic x-rays were reflected from the base material at one of the Bragg diffraction angles, and the diffracted intensity measured by a Geiger counter system. When the base material was covered with a thin coating, the x-rays were reduced in intensity according to the exponential absorption law for the coating material. From the measured ratio of intensities for the coated and uncoated backing, the geometry of the arrangement, and the known absorption coefficient for the coating, it was possible to compute the thickness of the coating. Measurements were made with a powder diffraction spectrometer[1] utilizing the focusing principle. The area of specimen covered by the x-ray beam was varied between one square centimeter and one square millimeter. Metal plating thicknesses were determined in the range 10^{-5} to 10^{-2} centimeters. The method is generally applicable to coatings of any material or combination of materials whose x-ray absorption coefficients are known.

[1] H. Friedman, Electronics **18**, 132 (April, 1945).

C10. X-Ray Measurement of the Thickness of Silver Plating. R. B. GRAY, *Erie Resistor Corporation.*—The thickness of a plated metal layer can be determined by comparing the intensities of the back-reflection lines of the base metal and the plated metal. The intensity ratio is

$$\frac{i_p}{i_B}=\frac{k_p}{k_B}\cdot\frac{\mu_B(1+\sec\theta_B)}{\mu_p(1+\sec\theta_p}\cdot[\exp(-\mu_p(1+\sec\theta_B)p)-\exp(-\mu_p(\sec\theta_B-\sec\theta_p)p)].$$

A photograph of silver plated brass was made using Fe $K\alpha$ radiation. The 311 planes were found to be most suitable for comparison. The x-ray method indicated a thickness of 2.2 microns. Chemical stripping of the whole piece indicated a thickness of 3.3 microns. This difference is due to the extra build-up which occurs at the corners of plated pieces.

FRIDAY AFTERNOON AT 2:15 O'CLOCK

Room 101, Wayman Crow Hall

(HARVEY FLETCHER presiding)

First Session of the Symposium in Celebration of the Fiftieth Anniversary of the Discovery of X-Rays

S1. The Birth and Early Infancy of X-Rays. G. E. M. JAUNCEY, *Washington University.*

S2. The Diffraction of X-Rays by Elements in the Liquid State. N. S. GINGRICH, *University of Missouri.*

S3. Studies of the Structure of Metals by X-Ray Diffraction. C. S. BARRETT, *Carnegie Institute of Technology.*

S4. X-Ray Diffraction Study of the Structure of Glass. B. E. WARREN, *Massachusetts Institute of Technology.*

FRIDAY EVENING AT 7:00 O'CLOCK

Gatesworth Hotel

Dinner of the American Physical Society

(HARVEY FLETCHER presiding)

SATURDAY MORNING AT 10:15 O'CLOCK

(Room 101, Wayman Crow Hall

(HARVEY FLETCHER presiding)

Second Session of the X-Ray Symposium

S5. The Scattering of X-Ray Photons. A. H. COMPTON, *Washington University.*

S6. Evolution of the X-Ray Tube; Powder Metallurgy. A. W. HULL, *General Electric Company.*

S7. An Investigation of Radiography in the Range from 500 to 2500 Kilovolts. R. J. VAN DE GRAAFF, W. W. BUECHNER, H. FESHBACH, A. SPERDUTO, E. A. BURRILL, AND L. R. MCINTOSH, *Massachusetts Institute of Technology.* (To be given by Mr. Van de Graaff.)

S8. X-Ray Therapy. G. FAILLA, *Columbia University.*

SATURDAY AFTERNOON AT 2:15 O'CLOCK

Room 101, Wayman Crow Hall

(E. U. CONDON presiding)

Closing Session of the X-Ray Symposium

S9. Some Problems of Thick and Thin Targets. PAUL KIRKPATRICK, *Stanford University.*

S.10. Present Status of the Value of h/e from X-Ray Measurements. J. W. M. DUMOND, *California Institute of Technology.*

S11. Structure in High-Frequency Limit of Continuous X-Ray Spectrum, and Value of h/e. J. A. BEARDEN, *Johns Hopkins University.*

S12. Spectral Fine Structure and its Relation to the Physical State. C. H. SHAW, *Johns Hopkins University.*

Saturday Afternoon at 2:15 o'clock

Room 104, Wayman Crow Hall

(A. L. Hughes presiding)

D1. Note on Accelerational-Velocital Magnetic Forces. F. W. Warburton, *University of Kentucky.*—Additional symmetric $1/c^3$ terms in the mutual force of two charges, obtained with the general Lagrangian equation and relative potential energy, give zero average force and torque of a conduction electron on a circular electronic orbit, when local variations in force are neglected. This periodic disturbance of the electron in the orbit—which disappears for alinement of orbital axes parallel and antiparallel to current in the rod—is of the order of one to ten percent of the applied magnetizing force in the experiments showing the "shock effect." The factor containing velocity of one charge and acceleration of the other suggests that local variation of this force on noncircular orbits may account for the change in magnetization in nickel, found by Perkins, which reverses with the velocity or acceleration of the conduction electrons. As another argument for the more general basic force formula for charges, the restriction in the $1/c^3$ terms imposed by classical propagation of the non-reciprocal magnetic force in $1/c^2$, is compared with restrictions in $1/c^2$ magnetic terms which would be imposed by propagation of the electrostatic force alone.

D2. A Study of Stationary Electromagnetic Modes for Region Between Parallel Perfectly Conducting Planes and Application to Electron Accelerator. E. S. Akeley, *Purdue University.*—The fundamental stationary *TM* modes possessing circular symmetry relative to axis perpendicular to planes are found. The relative intensity of modes are fixed by perfectly conducting surface of revolution $y(z)$ connecting planes; y is radius of one surface and z distance from one plane. There are three types of modes $\lambda_0<\lambda_1$, $\lambda_0=\lambda_1$, $\lambda_0>\lambda_1$ where λ_0 is wave-length in absence of planes and λ wave-length on axis between planes. Simultaneous excitation of modes $\lambda=\lambda_0$ and $\lambda=\lambda_0/2n+1$ is treated. Requirement *y finite* fixes relative intensity for given $y(0)$ and makes surface meet planes at right angles. If $y(0)>Y$ (Y depending only on n), surface deviates only slightly from that for one mode $\lambda=\lambda_0$ except in neighborhood of planes. If $y(0)<Y$ surface has $2n$ cusps. Numerical integration is used to determine shapes of surfaces and their relative dissipation of energy—an important consideration in design of electron accelerator. In accelerator only the mode $\lambda=\lambda_0$ causes acceleration of electron, the other mode is required to keep size of cavity finite.

D3. A Comparison of the High Frequency Accelerator and Betatron as a Source of High Energy Electrons. J. R. Woodyard, *Purdue University.*—A cavity resonator consisting of a long cylinder oscillating in a high order longitudinal electric mode may be used as a linear accelerator of electrons, provided electrical loading is added to give the nodes the required spacing. Typical methods of loading are compared. The average power requirements can be brought down to reasonable values by driving the resonator in short bursts instead of continuously, as is well known in ionosphere work. By making the resonator sufficiently long, any energy can be obtained, at least in principle. The total cost should vary directly as the length and therefore as the electron energy for such an accelerator. With a betatron, on the other hand, the weight and cost vary approximately as the cube of the energy. Therefore, above some value of electon voltage, the linear accelerator would be preferable from the standpoint of cost. More or less crude estimates place the cross-over point around 100 megavolts. In addition, the linear accelerator excels in ease of bringing out a beam of electrons, in case internal target bombardment is not desired. Approximate numbers are given for the amount of power required in terms of electron voltage and tube length.

D4. Effect of Transverse Pressure on the Steady-State Electrical Conductivity of Rocksalt. Charles N. Hamtil,* *St. Louis University.*—The effect of transverse pressure on the steady-state electrical conductivity of rocksalt was investigated in the temperature range 300–317 deg. C. The change in resistivity of the crystal when subjected to pressure was determined from the change in deflection of a high-sensitivity galvanometer in the crystal circuit. The e.m.f. applied to the crystal was 100 volts d.c. Pressure was applied to the crystal in a direction normal to the straight line joining the two electrodes, by means of flat steel plates insulated from the crystal. It was found that when transverse pressure of 33 kg/cm^2 is applied to a crystal, there results an increase in conductivity whose magnitude is approximately 7 percent of the steady-state conductivity of the unloaded crystal. The effect is attributed to a lowering by pressure of the counter-e.m.f. of polarization. It is suggested that the application of pressure causes some ions in the "polarization layers" to return to normal lattice positions.

* Now at Rockhurst College, Kansas City, Missouri.

D5. Investigation of the Surface Photoelectric Effect of Metallic Films under the Influence of Strong Electrostatic Fields. Vincent P. Jacobsmeyer, S.J., *St. Louis University.*—This investigation was a preliminary test of the Guth-Mullin[1] theory of the "photoelectric analog of the Schottky effect." The variation of the photoelectric current with strong electrostatic fields (at least to 1.4×10^5 volts/cm) was observed for various conditions of the photoelectric surface and for different cathode-anode geometries. The emission surfaces were Bi films of approximately 900 and 500 atom-layers respectively, deposited at room temperature by evaporation in high vacuum on a surface of liquid bright Pt, and also a liquid

bright Pt surface not covered with Bi. The photoelectric currents for sixteen runs fluctuate about a fixed reference "Schottky line" (the most probable straight line through the experimental points as calculated by the method of least squares). A comparison of the position of the maxima and minima of the curves obtained is made with the experimental thermionic results of Seifert and Phipps[2] and the theoretical derivations for the photoelectric by Guth and Mullin.[1] It is concluded that a real variation of photoelectric current with applied electric field is observed which has the approximately periodic character predicted by Guth and Mullin.[1]

[1] E. Guth and C. J. Mullin, Phys. Rev. **59**, 575 (1941).
[2] R. L. E. Seifert and T. E. Phipps, Phys. Rev. **56**, 652 (1939).

D6. Initiation of High Frequency Gas Discharges. T. HOLSTEIN, *Westinghouse Research Laboratories.*—A general characteristic of gas discharges in electric fields of microwave frequencies ($\omega > 3000$ megacycles/sec.) is that the drift motion of electrons in one period is much smaller than the linear dimensions of the discharge region. Under these conditions the only important cause of electron removal in gases which do not attach electrons is diffusion to the walls. The sparking condition is: rate of ionization > rate of diffusion. In a discharge region contained between two electrodes separated by a distance, d, and in a pressure range such that $\omega\tau_i > 1$, $\omega\tau_e < 1$, $d^2 \gg \lambda_i\lambda_e$ (where τ_e, τ_i, λ_e, and λ_i are the mean times and free paths for elastic and inelastic collision) the ionization and diffusion rates are the same as those which prevail in a spatially constant d.c. field whose magnitude is equal to the r.m.s. value of the high frequency field. The relation between X, the r.m.s. value of the sparking field, p, the pressure, and d, in terms of the electron temperature, T_e, and Townsend's α, is found to be

$$(pd)^2 = \pi^2 K T_e [(\alpha/p)(X/p)e]^{-1}.$$

This formula has been applied to obtain high-frequency sparking fields for a number of different gases.

D7. Extinction of Gaseous Discharges. ERNEST MAYER, *Westinghouse Research Laboratories.*—The role of ambipolar diffusion in the extinction of gaseous discharges has been investigated. On the assumptions of a Maxwellian distribution for electron energies and constant electronic mean free path, the electron temperature T_e decreases, due to elastic collisions with gas atoms, according to the formula

$$T_e = T_g \coth^2 ((T_g/T_0)^{\frac{1}{2}} + At),$$

with T_g the gas temperature, T_0 the initial electron temperature, and A a constant involving gas and electron parameters. For a simplified one-dimensional model of the discharge region the time and space dependence of the electron concentration n is

$$n = n_0 \cos\frac{\pi x}{d} \exp\left[-B\left(\frac{T_0/T_g}{(T_0/T_g)^{\frac{1}{2}} + \coth At} + 2At\right)\right],$$

where d is the electrode separation, B is a constant involving d and the gas and electron parameters. Curves of T_e/T_0 and n/n_0 *vs.* time are calculated for a neon discharge under typical operating conditions.

D8. Heat Conduction Effects with Liquid Crystals and Suspended Particles. G. W. STEWART, *State University of Iowa.*—The transverse orientation of liquid crystals in a heat flow is reviewed and the cause of the phenomenon is not found in differential temperature expansion, the momentum of high frequency acoustic waves, the anisotropic heat conduction in the liquid crystals and in unavoidable convection currents. The liquid crystals are not immersed in an isotropic liquid but it is interesting to note that tobacco virus and vanadium pentoxide floating in water do not show an orientation in heat flow.

D9. Rapid and Direct Measurement of Vapor Pressure of Liquid Metals. A. H. WEBER AND M. GONZAGA PLANTENBERG, O.S.B., *St. Louis University.*—Studies of various properties of thin metallic films have led to the development in this laboratory of a rapid direct method for measuring the vapor pressure of the liquid metals evaporated to form these films. The method employs a vacuum microbalance, consisting of a glass bucket hanging from an helical quartz spring,[1] of sensitivity 4.20×10^{-7} g/scale division. From kinetic theory the force F (of impact of a beam of atoms, issuing from an orifice of area dS, upon the bucket bottom which subtends the solid angle $d\omega$ at dS) is related to the vapor pressure p of the evaporating metals by

$$p = 2\pi F/dS d\omega.$$

F is measured directly by observing the decrease in length of the quartz spring when a shutter between the bucket bottom and the orifice dS is opened. The vapor pressure of a metal can be determined in 2–3 minutes compared to the many hours required in the previous method.[2] Preliminary results with Bi are reported and discussed.

[1] Gift of The General Electric Company.
[2] A. H. Weber and S. C. Kirsch, S.J., Phys. Rev. **57**, 1042 (1940).

SATURDAY AFTERNOON AT 2:15 O'CLOCK

Room 106, Wayman Crow Hall

(E. GUTH presiding)

E1. On a Statistical Approach to Biological Effects of Radiations. I. OPATOWSKI, *University of Chicago.*—The paper develops the idea of W. F. G. Swann[1] according to which the living matter undergoes under the effect of radiations a number of successive transitions between certain states 0, 1, $\cdots n$. By a biological mechanism the

organism may return spontaneously to its original state 0 through reverse transitions. Irradiation of an aggregate of microorganisms is considered under the assumption that the transition frequencies are constant in time but may be different for each single type of transition. Experiments give the percentage P of microorganisms accomplishing the transition $(0 \rightarrow n)$ within a time of radiation t. It is shown that any process admitting reverse transitions from some or from all states, except from the nth state, gives rise to the same relation $P(t)$ as a suitable process between the same states but without reverse transitions. Consequently, in order to obtain information on the biological reaction of the microorganisms, knowing $P(t)$ for several radiation intensities I, it is necessary to know also the dependence of the transition frequencies on I. The paper will appear in the December, 1945 issue of the *Bulletin of Mathematical Biophysics*.

[1] W. F. G. Swann and C. Del Rosario, J. Frank. Inst. 211, 303–317 (1931).

E2. Specific Heats of Hevea, GR-S and GR-I Polymers. B. A. Mrowca, R. L. Anthony, and W. H. Hamill, *Notre Dame University.*—A colorimeter, suitable for the rapid determination of specific heats of new polymers, is described. The results obtained have a precision much better than those obtained by simple mixture methods. Specific heat values are reported for Hevea and GR-S gum and tread stocks, for raw butyl (Butyl B-1.45) and for a butyl gum stock. It is shown by direct measurement that specific heats of compounded stocks can be calculated quite accurately by adding the fractional specific heats of the ingredients, and therefore do not need to be measured when the specific heat of the raw rubber is known. The specific heat of a standard carbon black (standard micronex) as it exists in the rubber is found to be 0.18 cal./g/1°C, a value identical with the specific heat of graphite. It is shown that for all rubbers upon which thermodynamic studies have been made the observed dependence of stress upon temperature requires that variations in C_L, the specific heat at constant length, with L be so small as to affect only the 4th significant figure in the specific heat.

E3. Fast Stress-Strain Machine. S. L. Dart, R. L. Anthony, and P. E. Wack, *Notre Dame University.*—It is of great importance in the study of rubber to obtain a stress-strain curve with sufficient rapidity that it may be relatively free from time effects. Such a curve may be used to give the stress-temperature relations of rubber and, in conjunction with adiabatic temperature rise measurements, to give the entropy and internal energy components of the stress. A machine which will record a complete stress-strain loop at the rate of about 100 percent a second and is relatively free from inertial effects has been developed in the Rubber Research Laboratory, University of Notre Dame. This machine uses the principle of a mechanical balance and has an accuracy of about 1 percent deviation from the mean. It shows not only the correct S shaped curve but also the correct temperature behavior for natural rubber. By the use of a special type clamp and of properly shaped samples true elongations can be read directly from the recorded clamp separations.

E4. Phase Transitions at Low Temperatures in Natural and Synthetic Rubber. Paul E. Wack, *Notre Dame University.*—Phase transitions in natural and synthetic gum stocks were studied at low temperatures ranging from +25°C to −75°C. Mechanical changes accompanying the phase transitions were observed, in particular the changes in stress with temperature and time at constant length of the sample, i.e., stress-relaxation, and isometrics, and the changes in length as a function of temperature and time at constant stress, i.e., creep and isotonics. An autographic stress-time-temperature machine was designed so that a maximum movement of the rubber of 0.1 mm would set the automatic balancing mechanism into action. This feature is of the highest importance for the observation of second order transitions. For Hevea gum, crystallization was observed at low temperatures for only those elongations above 200 percent. The maximum rate of crystallization occurred at −20°C. The stress-strain curve obtained by cross plotting the stress-temperature curves at −50°C for instance shows a "well," due to the decrease of stress upon crystallization, similar to the behavior of a van der Waals gas. Internal energy and entropy curves as a function of elongation were obtained from the stress-temperature curves. The data cover a wider range of variables than any of the data published hitherto.

E5. Mechanism of Natural Oxidation of Aluminum, Iron, and Copper. Scott Anderson, *Anderson Physical Laboratory.*—The author's theory of electrolytic oxidation of aluminum has been extended to include the natural oxidation of aluminum, iron and copper. When so applied, it appears that space charges control the rate of growth in the early stages. Equations are devised for the three stages of growth, (1) when the mean free path of the moving particles is large in comparison to the oxide thickness, (2) when the mean free path of the moving particles is small in comparison to the oxide thickness, and (3) when the oxide is so thick that space charges are no longer the controlling factor. These equations predict a third power law of rate of growth for stage 1, a fourth power rate for stage 2, and a quadratic law of growth for stage 3. The equations are compared with data of numerous experimenters and agree quite well with the observed rates.

E6. Forced Vibrations of a Whirling Wire.* A. Victor Masket, *Naval Research Laboratory.*—The method of the Laplace transformation and contour integration has been applied to obtain a series solution for the partial differential equation governing the transverse vibrations of a long thin wire subject to a combined static tension and centrifugal force when the moving end is forced to execute a sinusoidal motion. The novel features of the solution are first, the eigenfunctions are the transcendental Legendre functions and second, the functions are not orthogonal over any interval of the defined range of validity. The associated problem of resonance is solvable by the same technique.

* Published by permission of the U. S. Navy Dept.

E7. Helical Movements of Matter in the Beam of Light and the Magnetic Current. FELIX EHRENHAFT, *New York City.*—Photomicrographs of light-positive and light-negative helical movements of testbodies[1] in the concentrated beam of natural sunlight without and with superimposed homogeneous magnetic or electric field parallel to the propagation of light will be shown. There are up to 150 regular spaced turns per second in gas of atmospheric pressure. The diameter of the helical path is often 100 times larger than the radius of the moving testbody. The red end of the visible solar spectrum causes no noticeable photophoretic movement of smoke particles, whereas the end of visible blue-violet causes their light-negative movement (experiment, R. Whitall, H. W. Zieler). An iron particle, radius about 1.5×10^{-6} cm, describes in the horizontal homogeneous magnetic field of 50 gauss parallel to the concentrated natural beam of sunlight during half a second a helical path, the diameter of which is in average 2.7×10^{-3} cm; the average distance between the seven consecutive turns is 1.4×10^{-3} cm. Its photophoretic velocity without external magnetic field is about 1.1×10^{-2} cm/sec. Therefore the longitudinal magnetic field in this concentrated beam itself is approximately 64 gauss. The electric charge of the particle is about 1×10^{-9} e.s.u. The magnetic charge is about 2.5×10^{-12} m.s.e. The aforesaid movement gives evidence of electric action of magnetic current. The question of balance of energy responsible for these tremendous helical movements arises. The principle of conservation of linear and angular momentum of electrodynamics and the equation of F. Hasenoehrl $E=(4/3)mc^2$ for blackbody radiation, generalized later on by A. Einstein and applied for radioactive radiation, has to be radically modified for natural light.

[1] Science **101**, 676 (1945).

E8. A Quantitative Method for the Spectroscopic Analysis of Potassium-Sodium Solution. WAYNE SCANLON, *Purdue University.*—A rapid and accurate method of quantitative analysis of sodium and potassium was developed which gives direct measurement of concentrations ranging from 10 mg/100 cc to 200 mg/100 cc. The solution containing the sodium and potassium is sprayed into a flame where the resonance lines of these elements alone are appreciably excited. The resonance lines of sodium at 5890 and 5895A and those of potassium at 7664 and 7699A are separated enough in the spectrum to permit their isolation almost completely by means of color filters. The light from the flame is by this means separated, one color falling on a red sensitive photoelectric cell and the other on a yellow sensitive cell. The photoelectric current is measured by means of a high sensitive galvanometer. The illumination gas and air mixture that gave the most stable conditions was determined. These could be maintained steady enough to permit calibration of the galvanometer scale in terms of concentrations of potassium and sodium. The amount of solution required is small, as little as 1 cc being sufficient. The results obtained on test solutions showed errors not greater than about 3 percent to 5 percent.

E9. A New and Rapid Method for Constructing Quarter-Wave Plates, Half-Wave Plates, Half Shades and Ellipticity Compensators. WILFRIED HELLER, *University of Chicago.*—The traditional method of constructing such devices by splitting mica or by reducing calcite or quartz plates to the optimum or critical thickness, is both expensive and time consuming. For precision measurements at 5890A, for example, a Senarmont compensator must consist of mica 29.45 microns thick. A new and rapid method for obtaining such devices for any wave-length desired resulted from photoelastic investigations on polymer films, conducted in conjunction with Mr. H. Oppenheimer and to be published shortly. Films of certain plastics, such as polyethylene, acquire on stretching a birefringence which does not change on removing of the load. By varying the elongation between 0 and 200 percent, a permanent path difference of any magnitude within the limits of approximately 0A and 4×10^5A per one mm layer can be obtained. The method can be used for quarter-wave compensators, Laurent half shades, Bravais half shades, Chaumont quadruple field analyzers and for producing circularly polarized light from natural light. Noteworthy among the various other possible applications of the films is the substitution of the Johannsen comparator in work with the polarizing microscope by a slide containing a series of polymer films of systematically varied path difference.

E10. On the Self-Diffusion of a Pure Gas Through a Long Capillary when the Mean Free Path Is Comparable to the Capillary Diameter. R. D. PRESENT AND W. G. POLLARD, *SAM Laboratories, New York City.*—Knudsen* showed theoretically and experimentally that the flow of a pure gas through a long capillary of radius r at pressures so low that intermolecular collisions can be neglected is diffusive in character and the diffusion coefficient is $2v_0r/3$ where v_0 is the mean speed of the molecules. Mass motion sets in when the mean free path is comparable to r and at higher pressures the flow is laminar. Experimental plots of specific flow $(F/\Delta p)$ *vs.* mean pressure $\bar{p}$ are linear at high pressures ($\lambda\ll r$) but show a minimum in the neighborhood of $\lambda\approx r$. No satisfactory explanation of this minimum has hitherto been given. We have calculated the self-diffusion coefficient for "tagged" molecules diffusing in the absence of a pressure gradient; i.e., for the case of diffusion with no mass motion. The resulting formula is valid at all pressures and reduces to the correct limiting values: $v_0\lambda/3$ when $\lambda\ll r$ and $2v_0r/3$ when $\lambda\gg r$. Furthermore the theoretical curve of $F/\Delta p$ *vs.* $\bar{p}$ has a large negative slope for a long tube at pressures so low that no appreciable mass motion can occur. This explains the minimum found by Knudsen and others. The fact that this minimum is not observed when porous media are substituted for capillary tubes can also be explained.

* M. Knudsen, Ann. d. Physik **28**, 75 (1909).

SUPPLEMENTARY PROGRAMME

P1. The Theory of the Herschel-Quincke Tube. G. W. STEWART, *State University of Iowa.**—A former discussion of the theory of the Herschel-Quincke tube is continued and supplemented by the investigation of Professor H. S. Uhler of a more general case. With the areas of the bifurcated conduits different, it is found that the number of frequencies giving zero transmission is again more numerous than determined by the condition of a difference of phase corresponding to that of one-half wave-length in the two branches. In the more general case the former fixed relations between these phase differences no longer hold. They are now connected by the equality,

$$S_2 \sin a_3 = -S_3 \sin a_2,$$

where S_2 and S_3 are the areas and a_2 and a_3 the phase differences in the corresponding branches. Curiously, there may be zero transmission with branches of different areas.

* To be given after paper D9 if time permits.

P2. A Simple Apparatus for Demonstrating Fluorescence, Light Scattering, and Its Polarization and Depolarization. WILFRIED HELLER, *University of Chicago.**—A small, portable apparatus was constructed for demonstrating all essential features of these phenomena. Minor alterations would make the apparatus applicable to quantitative measurements. Starting with the light source, the essential parts of the apparatus are: collimator, heat filter, light filter, rotatable polaroid, cell containing the light scattering or fluorescent system, second polaroid rotatable around axis normal with respect to primary beam, and telescope. Using only the first of the removable polaroids, the change of Rayleigh radiation with the azimuth of the electric vector can be demonstrated; using only the second polaroid, a separation of light scattering and fluorescence can be effected in systems exhibiting both phenomena. With both polaroids, the four Krishnan components of multipolar radiation can be separated. By removing the telescope, the variation of light scattering with the angle of observation with respect to the primary beam can be followed. The existence of a Mie effect (dissymmetric radiation) in the case of multipolar radiation can be demonstrated. The apparatus is operated with interchangeable round cells of varied size, with square cells or with cells containing, for accurate work, a Rayleigh horn. Conservative absorption due to light scattering can be studied in the direction of the primary beam.

* To be given after paper E9 if time permits.

TO BE READ BY TITLE

T1. On the Deviation of the Biological Effects of Radiations from the Bunsen-Roscoe Law. I. OPATOWSKI, *University of Chicago.*—The effect of a radiation depends often not only on the total energy absorbed but also on its time distribution. To explain this it is assumed that the effect of radiations consists of successive transformations between a certain number of states 0, 1, $\cdots n$ and that these transformations follow a simple probabilistic model, which from a mathematical viewpoint is a generalization of the classical type of radioactive disintegrations. The transitions $(i-1 \rightarrow i)$ and $(i+1 \rightarrow i)$ are interpreted respectively as due to the action of radiation and to the biological reaction of the organism. The frequencies of these transitions are assumed respectively to be in a direct proportion to the radiation intensity I and to decrease as I increases. Then the probability that the organism be in the state n after a time t of radiation depends on It only, if t is sufficiently small but not if t is large. The result may be applied also to some types of photochemical processes. The paper is a part of an article to appear in the December, 1945 issue of the *Bulletin of Mathematical Biophysics*.

Please tear along this line.

(To be sent promptly to Professor A. L. Hughes, Washington University, St. Louis 5, Missouri)

I EXPECT to attend the dinner of the American Physical Society at the Gatesworth Hotel, St. Louis, at seven o'clock on Friday evening, November 30, 1945. My party will consist of ____ persons.

_____